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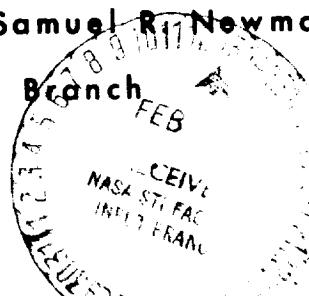
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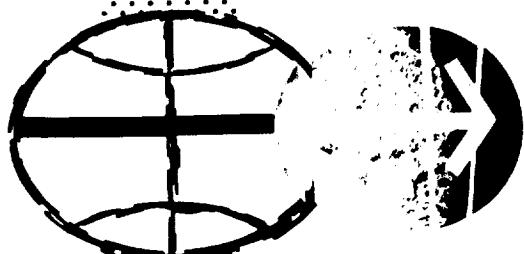
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APOLLO 6 (A-2 OR AS-502/020) OPERATIONAL MODE I LAUNCH ESCAPE VEHICLE ABORT PLAN

By Dallas G. Ives and Samuel R. Newman,
Flight Analysis Branch



MISSION PLANNING AND ANALYSIS DIVISION



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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Apollo 6 (A-2 OR AS-502/020) OPERATIONAL MODE I

LAUNCH ESCAPE VEHICLE ABORT PLAN

By Dallas G. Ives and Samuel R. Newman

SUMMARY

Mode I launch escape vehicle (LEV) aborts from the Saturn V vehicle launched from complex 39, pad A, exist from lift-off to tower jettison at 184.78 seconds ground elapsed time (g.e.t.). The mode I LEV abort cases for this document assumed a nominal launch vehicle trajectory, nominal LEV performance, and no winds. The mode I LEV landing points exist from near the pad to approximately 493-n. mi. down range from the launch complex. The highest altitude achieved from a mode I LEV abort is approximately 462 266 ft and occurs at the 184.78-second abort case. The mode I LEV abort data are considered adequate for positioning of recovery forces. These mode I LEV aborts do not violate any known spacecraft constraints.

INTRODUCTION

This document presents the operational mode I LEV abort plan for the Apollo 6 (A-2 or AS-502/020) mission. Modes II, III, and IV abort plans are presented in reference 1.

The LEV is designed to accelerate the command module (CM) away from the launch vehicle to a safe separation distance and far enough down range from the launch pad for safe water landings. This procedure is designated a mode I LEV abort. It covers the portion of the powered flight trajectory in which there is a high probability of an abort requiring rapid separation and acceleration of the CM away from the launch vehicle. These aborts are characterized by high accelerations induced by the launch escape motor (LEM) and high aerodynamic forces induced by the atmosphere at low altitudes.

Mode I LEV aborts exist from lift-off until the launch escape tower (LET) is jettisoned at 184.78 seconds g.e.t. They are subdivided into low, medium, and high altitude abort regions. Each region has its own distinct abort sequence of events.

ANALYSIS

The analysis was conducted using the Saturn V AS-502 launch vehicle operational flight trajectory (ref. 2) and the mission data specification document (ref. 3). The launch escape vehicle configuration is presented in figure 1. This analysis assumed a nominal launch vehicle trajectory, nominal LEV performance, and no winds on the abort trajectories.

The following is a summary of the mode I LEV abort sequences.

(a) Mode IA (0 to 41 seconds g.e.t.)

T = 0	Fire launch escape motor and pitch control motor.
T + 11 sec	Deploy canards.
T + 14 sec	Jettison tower and boost-protective cover.
T + 14.4 sec	Jettison apex cover.
T + 16 sec	Deploy drogue chutes.
T + 28 sec	Deploy main chutes if the g.e.t. < 38 seconds.
10 500-ft altitude	Deploy main chutes if the g.e.t. <u>></u> 38 seconds.

(b) Mode IB (end of mode IA to 64 seconds g.e.t.)

T = 0 sec	Fire launch escape motor, pitch control motor is not ignited after 41 sec.
T + 11 sec	Deploy canards.
T + 14 sec	Jettison tower and boost-protective cover.
T + 14.4 sec	Jettison apex cover.
T + 16 sec	Deploy drogue chutes.
10 500-ft altitude	Deploy main chutes.

(c) Mode IC (end of mode IB to the time of tower jettison)

T = 0 sec	Fire launch escape motor.
T + 11 sec	Deploy canards.
23 300-ft altitude + .01 sec	Jettison tower and boost-protective cover.
23 300-ft altitude + 0.41 sec	Jettison apex cover.
23 300-ft altitude + 2 sec	Deploy drogue chutes.
10 500-ft altitude	Deploy main chutes.

These sequences are presented in figure 2.

RESULTS

Table I presents a summary of the Apollo 6 mode I LEV abort trajectories.

Figures 3, 4, 5, and 6 present altitude versus range for aborts from the pad, at 41 seconds g.e.t. (end of mode IA), at 64 seconds g.e.t. (end of mode IB), and at 184.78 seconds g.e.t. (end of mode IC).

Figure 7 presents mode I LEV abort landing points for aborts off the pad through 65 seconds g.e.t. These landing points shift as the launch vehicle goes through its roll program. At approximately 11 seconds g.e.t., the launch vehicle rolls from 90° east of north to a flight azimuth of 72°, which is achieved at approximately 38 seconds g.e.t. Since this analysis did not include winds, all of the aborts have landing points in water. However, the landing points for aborts off the pad through 15 seconds g.e.t. are in the region where the water is less than 10 ft deep at low tide.

Figure 8 presents mode I LEV abort landing points for 70 seconds through 184.78 seconds g.e.t. All of the landing points are in water, and the landing point for the 184.78-second abort (end of mode I LEV abort) is approximately 493-n. mi. down range.

Figures 9 through 12 present various mode I LEV trajectory characteristics. Figure 9 presents apogee altitude as a function of abort altitude. Figure 10 presents time of landing as a function of time of abort. Figure 11 presents total load factor as a function of abort altitude; this figure shows two plots, total load factors during entry and during LEM thrust. The total load factor is the resultant magnitude of the X, Y, and Z loads. Note that the maximum load factor, 13.7g, occurs during entry. Figure 12 presents the total load factor time history for a mode I LEV abort at 184.78 seconds g.e.t.

CONCLUSIONS

1. Mode I LEV aborts for the Apollo 6 mission have water landings from near the pad to approximately 493-n. mi. down range.
2. If there are no winds, landing points for aborts off the pad through 15 seconds g.e.t. are very near the beach (470 ft) and in water that is less than 10 ft deep at low tide.
3. An on-shore wind of any magnitude will probably shift the near pad mode I LEV abort landing points onto the beach.
4. The mode I LEV abort data presented in this document are considered adequate for positioning of recovery forces. The data will be updated in real time by the mode I LEV real-time landing point prediction program using measured wind data prior to launch.
5. The mode I LEV aborts do not violate any known spacecraft constraints.

TABLE I.- SUMMARY OF THE APOLLO 6 MODE 1 (REV) ABORT TRAJECTORIES

(a) Mode 1A aborts

Abort time, min:sec	Abort altitude, ft	Abort apogee altitude, ft	Landing range, ft	Landing point		g.e.t. to landing point, min:sec
				Geodetic latitude, deg:min N	Longitude, deg:min W	
00:00	423	5013	4161	28:36.41	80:35.49	01:54
00:10	861	6163	4255	28:36.41	80:35.47	02:49
00:20	2329	8635	4101	28:36.50	80:35.49	01:24
00:30	5055	12 189	5712	28:36.60	80:35.21	01:06
00:40	9308	17 365	9079	28:36.85	80:34.61	00:34
00:41	9826	17 955	9335	28:36.87	80:34.57	00:38

(b) Mode 1B aborts

Abort time, min:sec	Abort altitude, ft	Abort apogee altitude, ft	Landing range, n. mi.	Landing point		g.e.t. to landing point, min:sec
				Geodetic latitude, deg:min N	Longitude, deg:min W	
00:42	13 365	19 199	1.47	28:36.81	80:34.63	00:45
00:50	15 342	24 744	2.27	28:37.05	80:33.76	01:13
01:00	23 301	33 216	3.69	28:37.47	80:32.21	01:59
01:04	27 152	37 656	4.42	28:37.67	80:31.42	02:08

(c) Mode 1C aborts

Abort time, min:sec	Abort altitude, ft	Abort apogee altitude, ft	g.e.t. to 23 300-ft altitude, min:sec	Landing range, n. mi.	Landing point		g.e.t. to landing point, min:sec
					Geodetic latitude, deg:min N	Longitude, deg:min W	
01:05	28 153	39 461	02:08	5.56	28:37.95	80:30.17	07:52
01:10	33 477	47 723	02:28	7.47	28:38.47	80:28.08	08:11
01:19	45 812	69 055	03:11	14.19	28:40.42	80:20.77	08:53
01:31	60 517	100 826	04:01	29.33	28:44.72	80: 4.27	09:43
01:40	77 506	144 240	04:53	63.99	28:54.68	79:26.49	10:56
01:51	96 768	192 841	05:38	102.94	29: 5.96	78:44.00	11:11
01:57	118 528	245 784	06:18	162.01	29:23.04	77:39.39	11:58
02:10	142 812	304 031	07:00	235.95	29:43.31	76:17.93	12:42
02:20	169 781	370 688	07:44	329.68	30: 8.20	74:34.00	13:26
02:30	199 437	431 528	08:24	423.78	30:31.06	72:48.60	14:06
02:40	228 493	440 926	08:32	441.08	30:35.89	72:29.36	14:14
02:50	255 757	450 201	08:40	461.74	30:41.44	72: 6.30	14:22
03:00	281 325	458 460	08:48	482.38	30:46.99	71:43.22	14:30
03:04.78	292 956	462 266	08:52	492.53	30:49.69	71:31.87	14:34

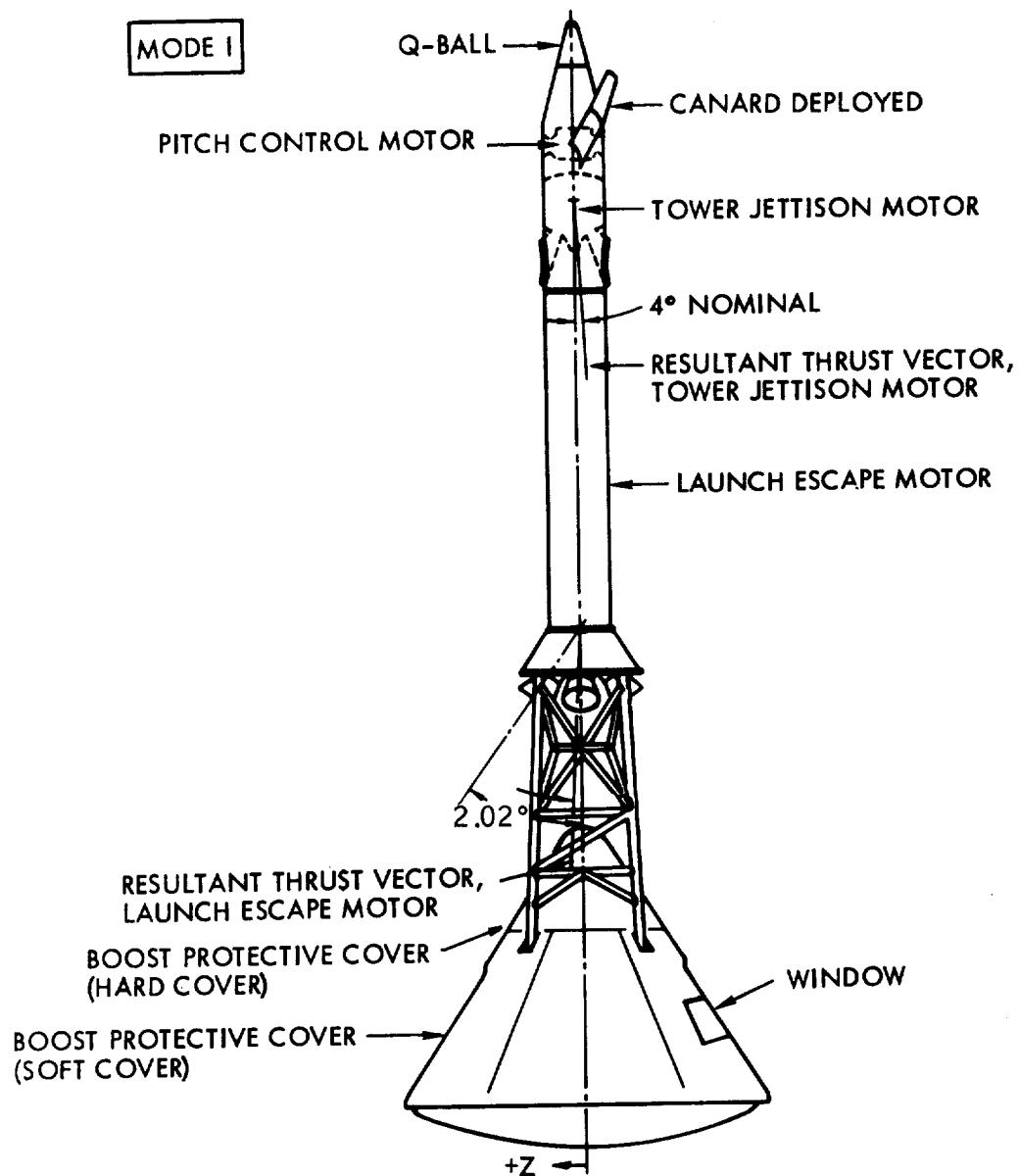
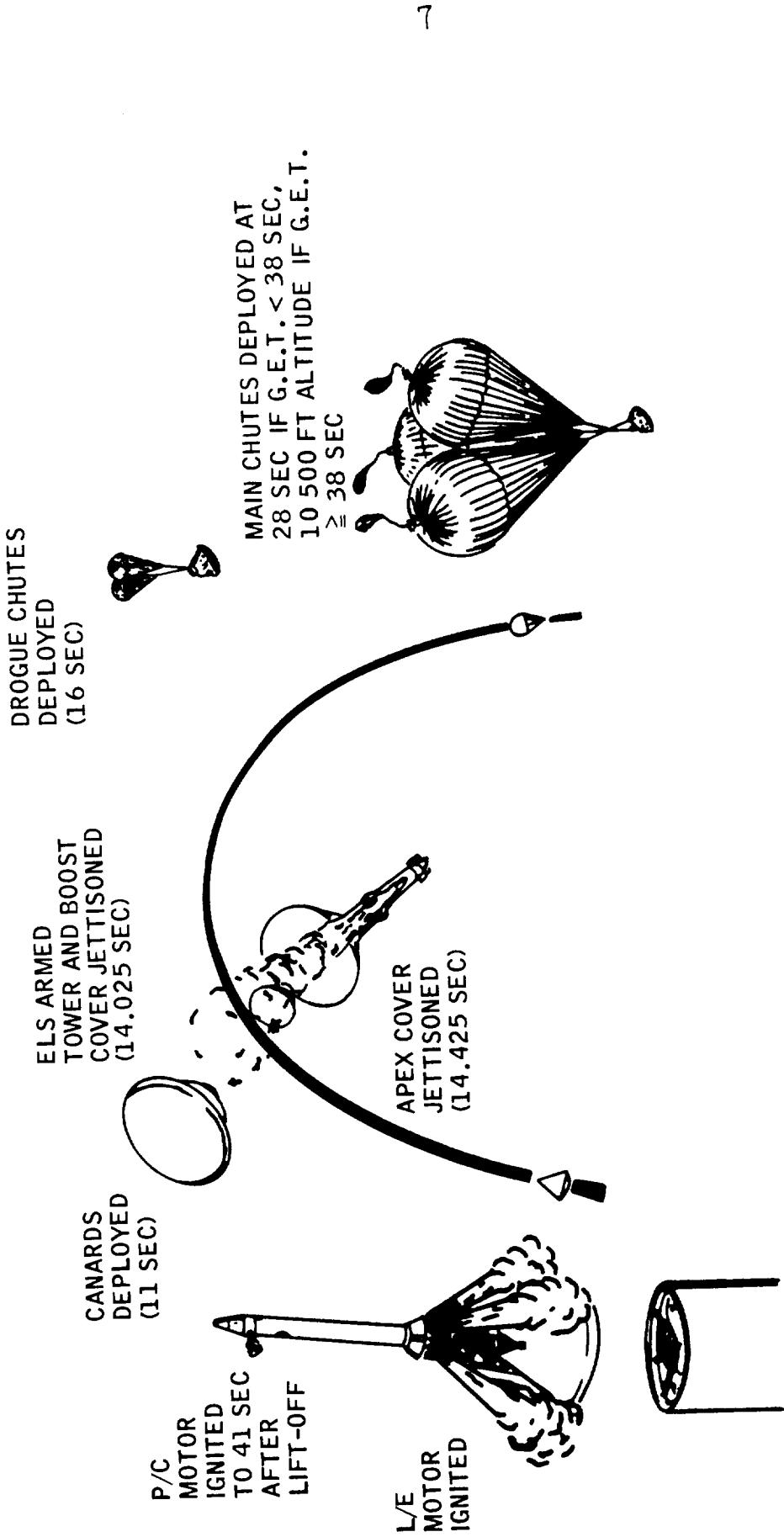
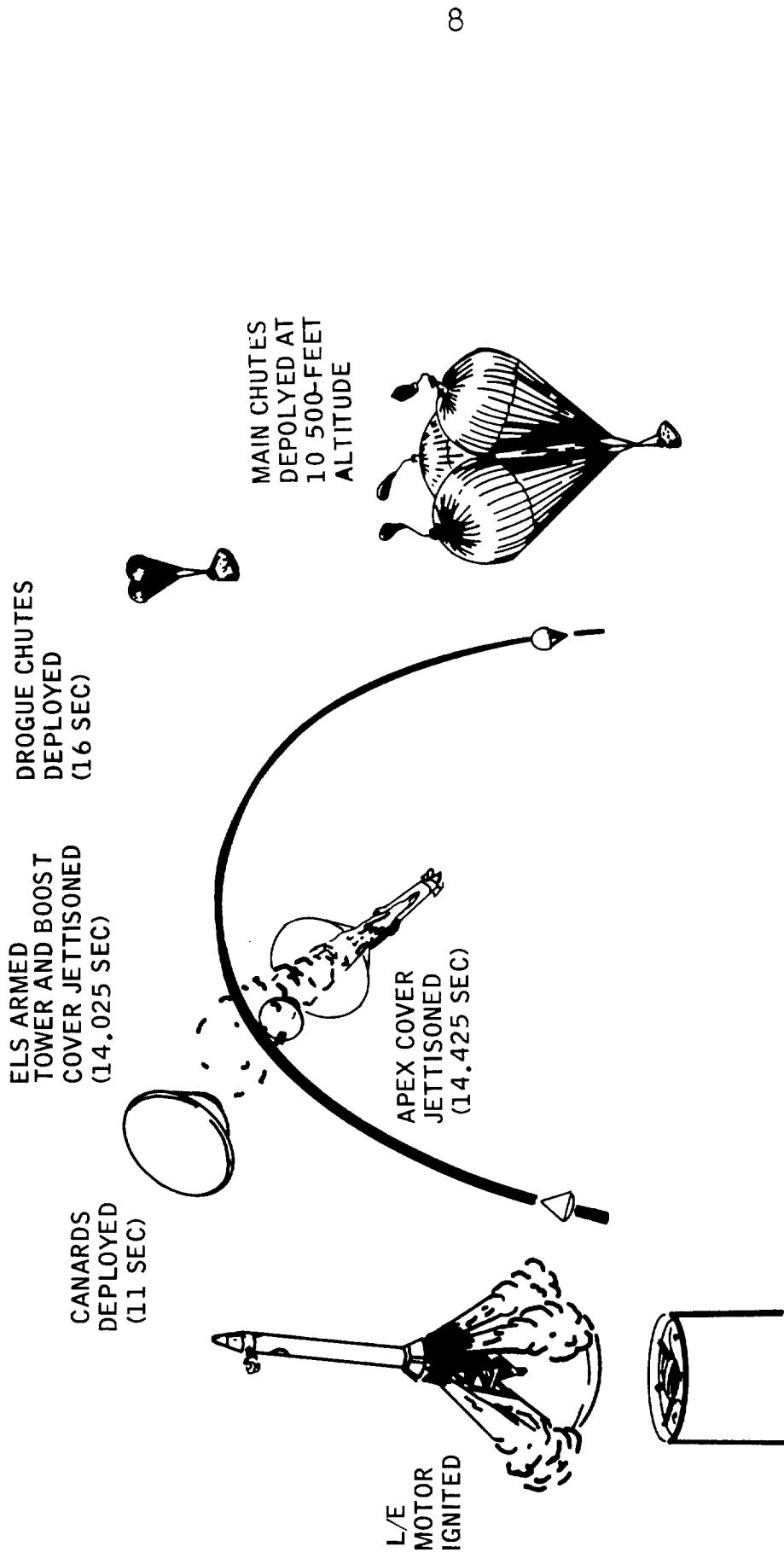


Figure 1.- Launch escape vehicle configuration.



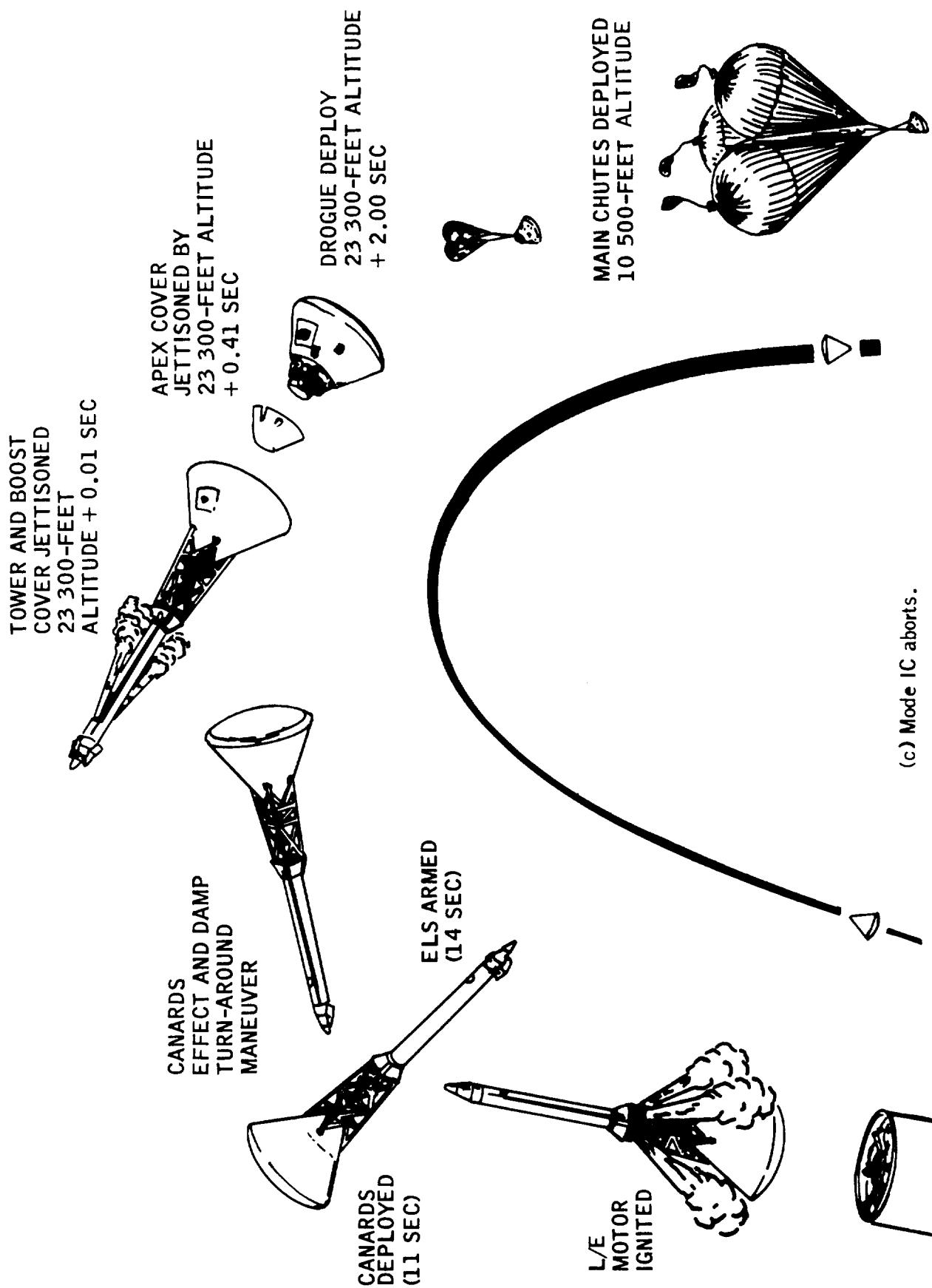
(a) Mode 1A aborts.

Figure 2.- LEV abort sequences.



(b) Mode IB aborts.

Figure 2.- Continued.



(c) Mode IC aborts.

Figure 2.- Concluded.

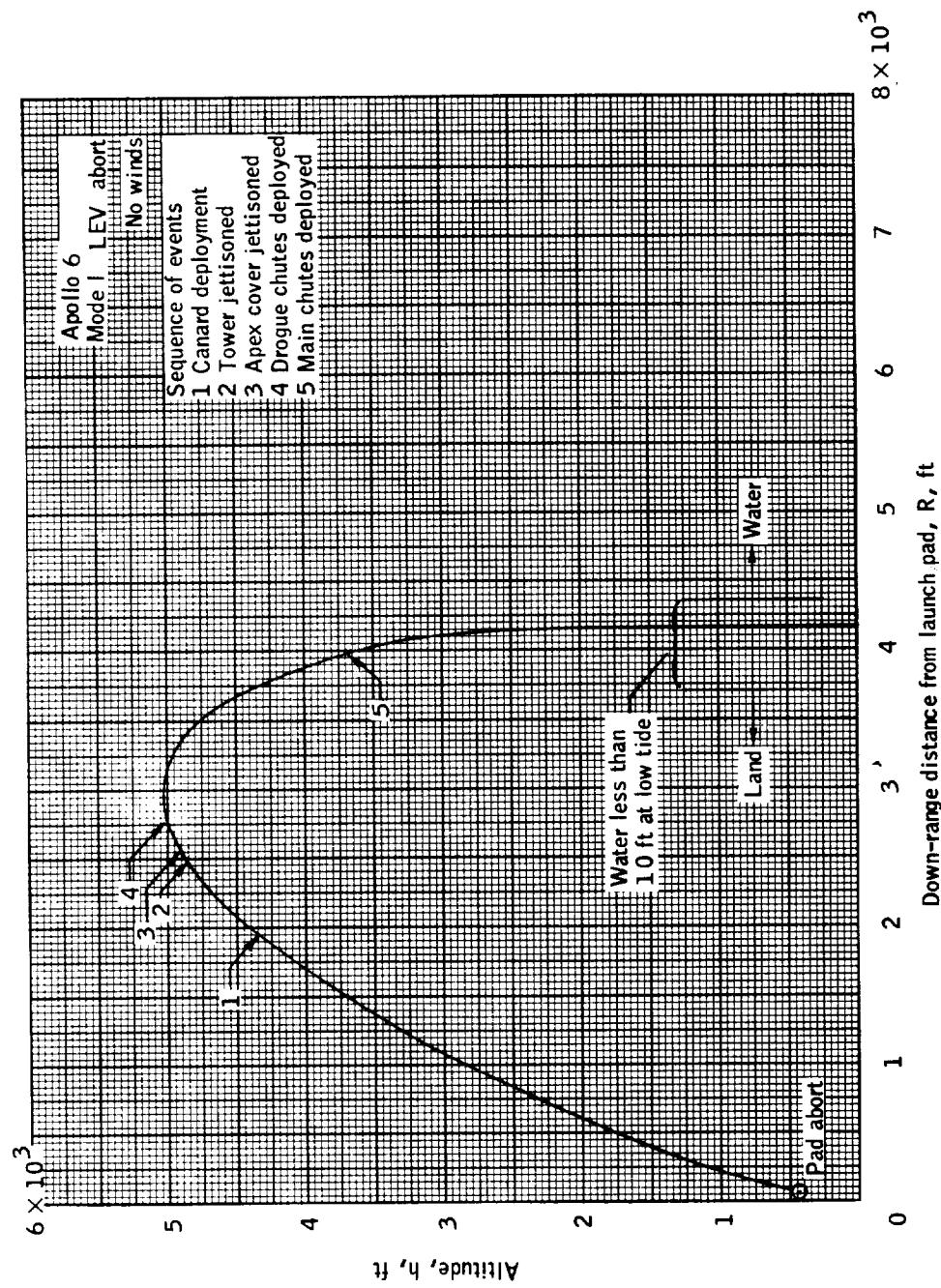


Figure 3. - Altitude versus down-range distance for a mode 1 LEV pad abort.

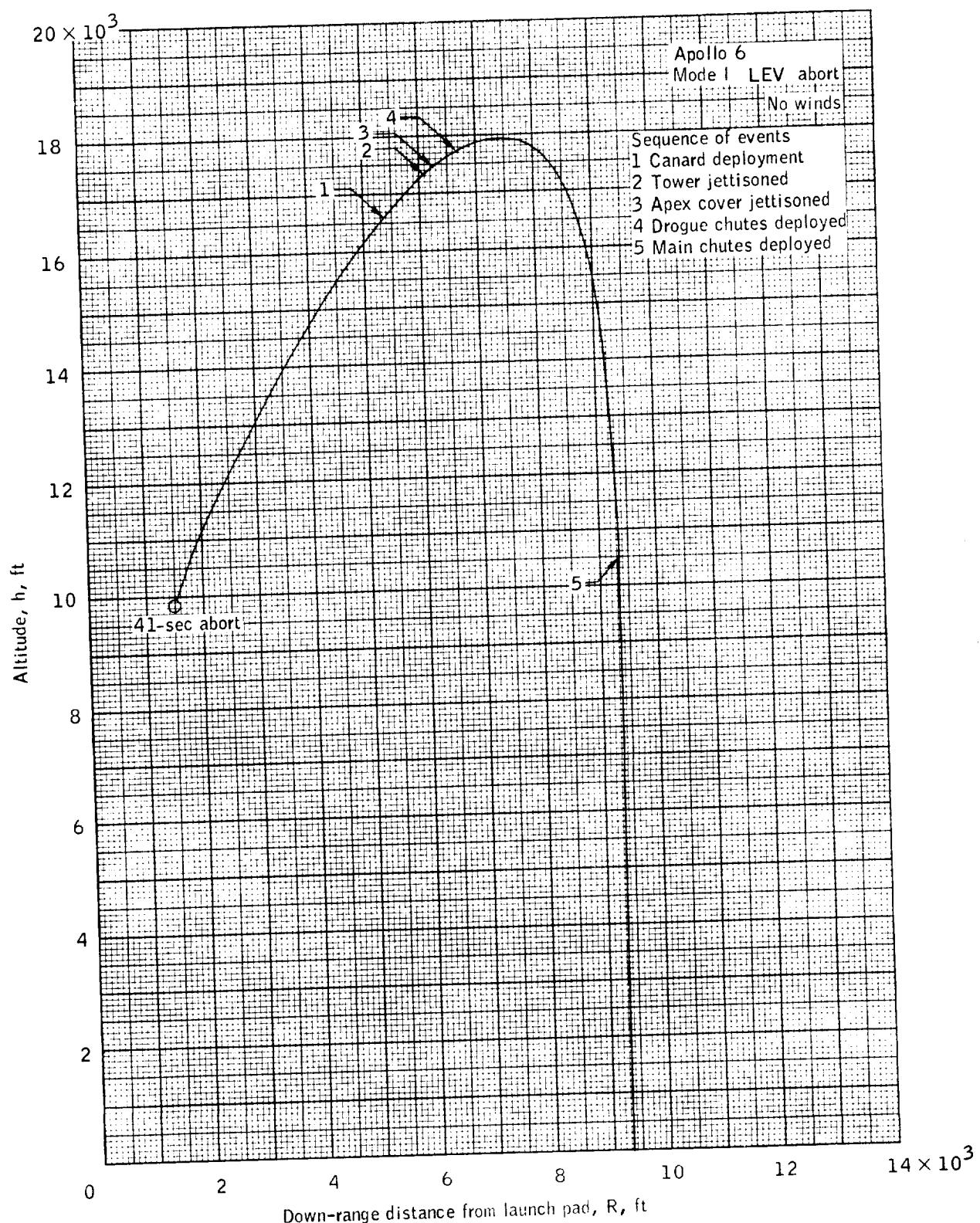


Figure 4.- Altitude versus down-range distance for a mode 1 LEV 41-second abort (end of mode 1A aborts).

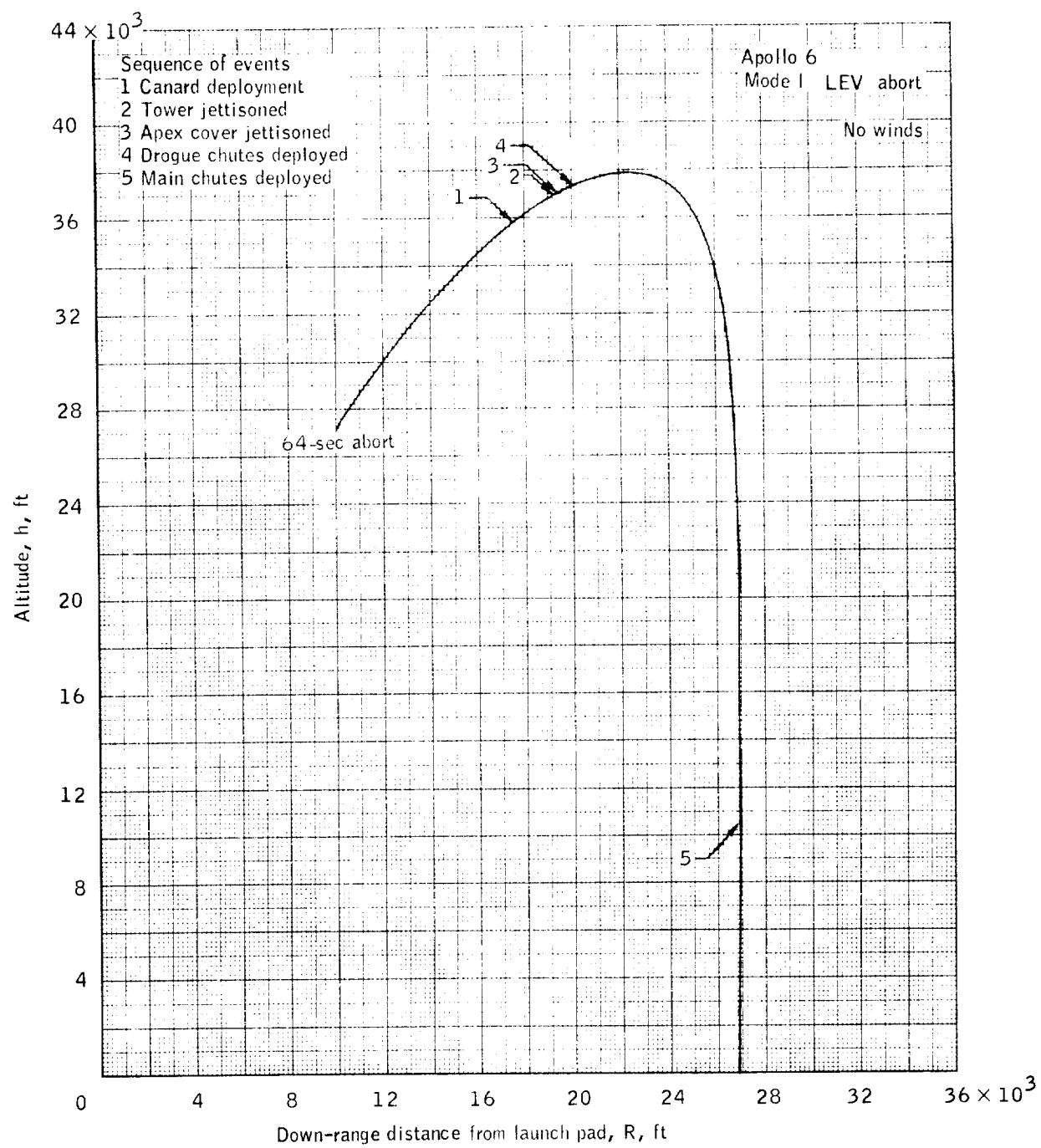


Figure 5.- Altitude versus down-range distance for a mode 1 LEV 64-second abort (end of mode 1B aborts).

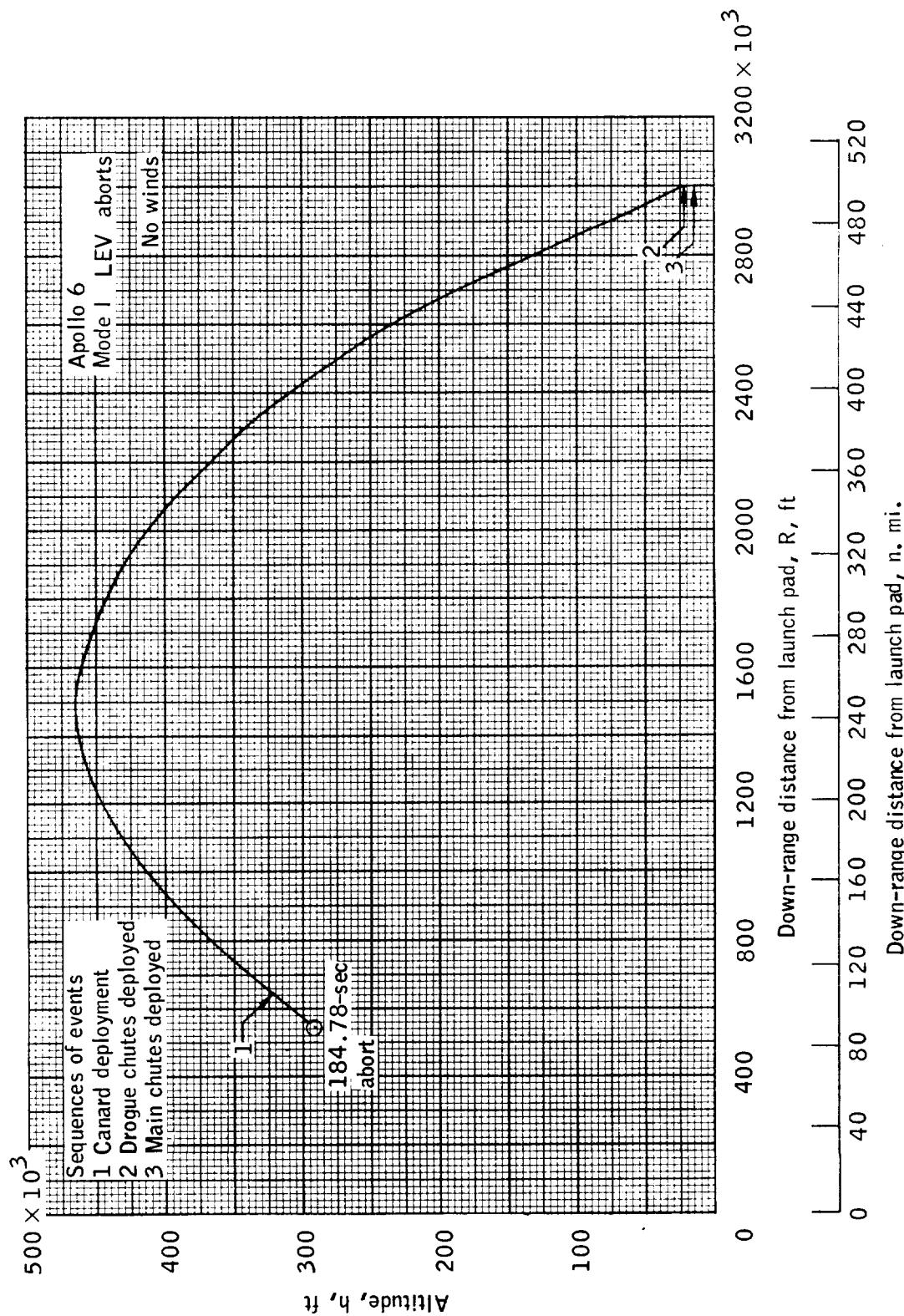


Figure 6.- Altitude versus down-range distance for a mode I LEV 184.78-second abort (end of mode 1C aborts).

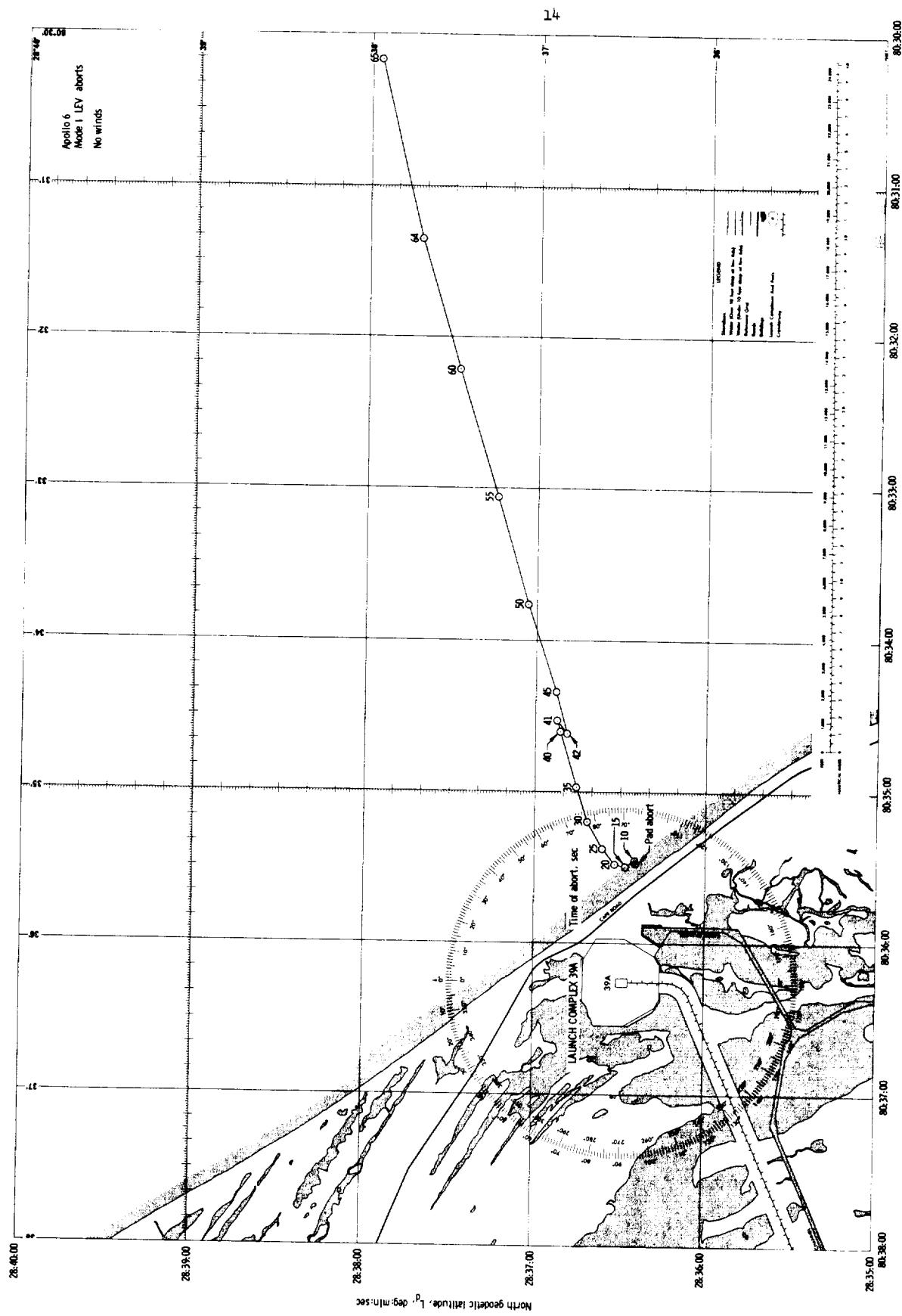


Figure 7. - Mode I LEV abort landing points for pad abort through 65 seconds ground elapsed time.

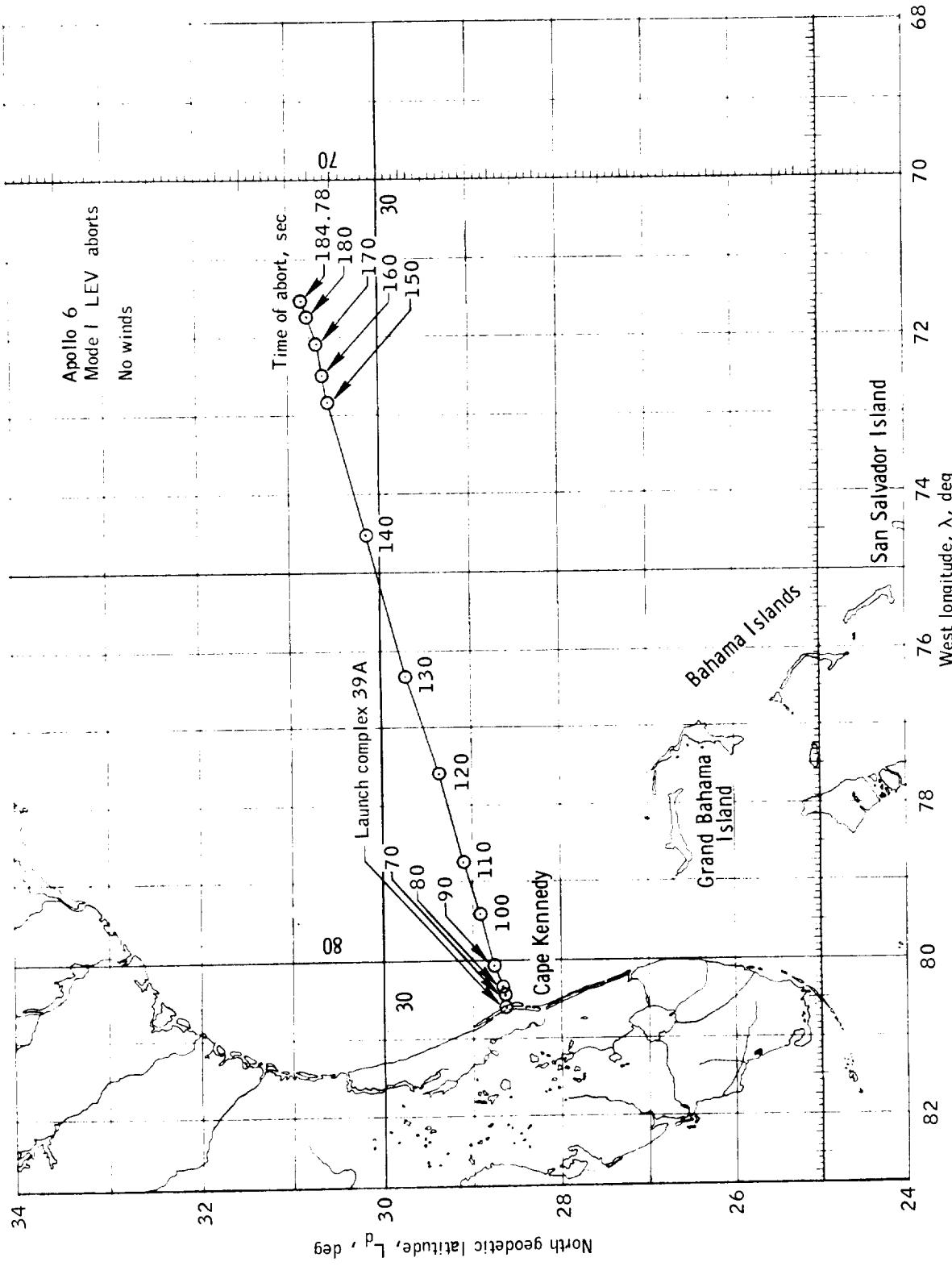


Figure 8. - Mode I LEV abort landing points for 70 seconds through 184.78 seconds ground elapsed time.

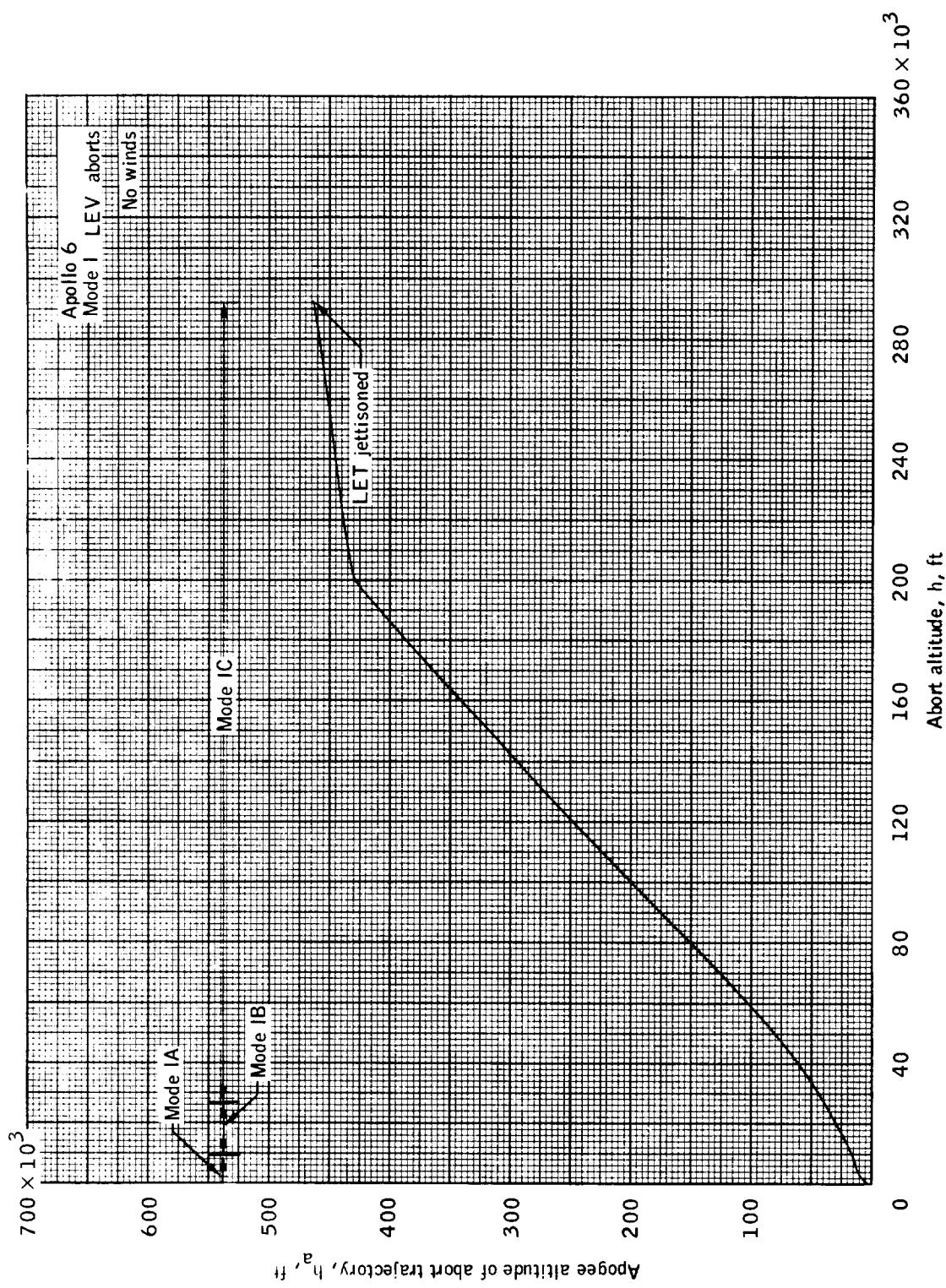


Figure 9. - Apogee altitude as a function of abort altitude for mode I LEV aborts.

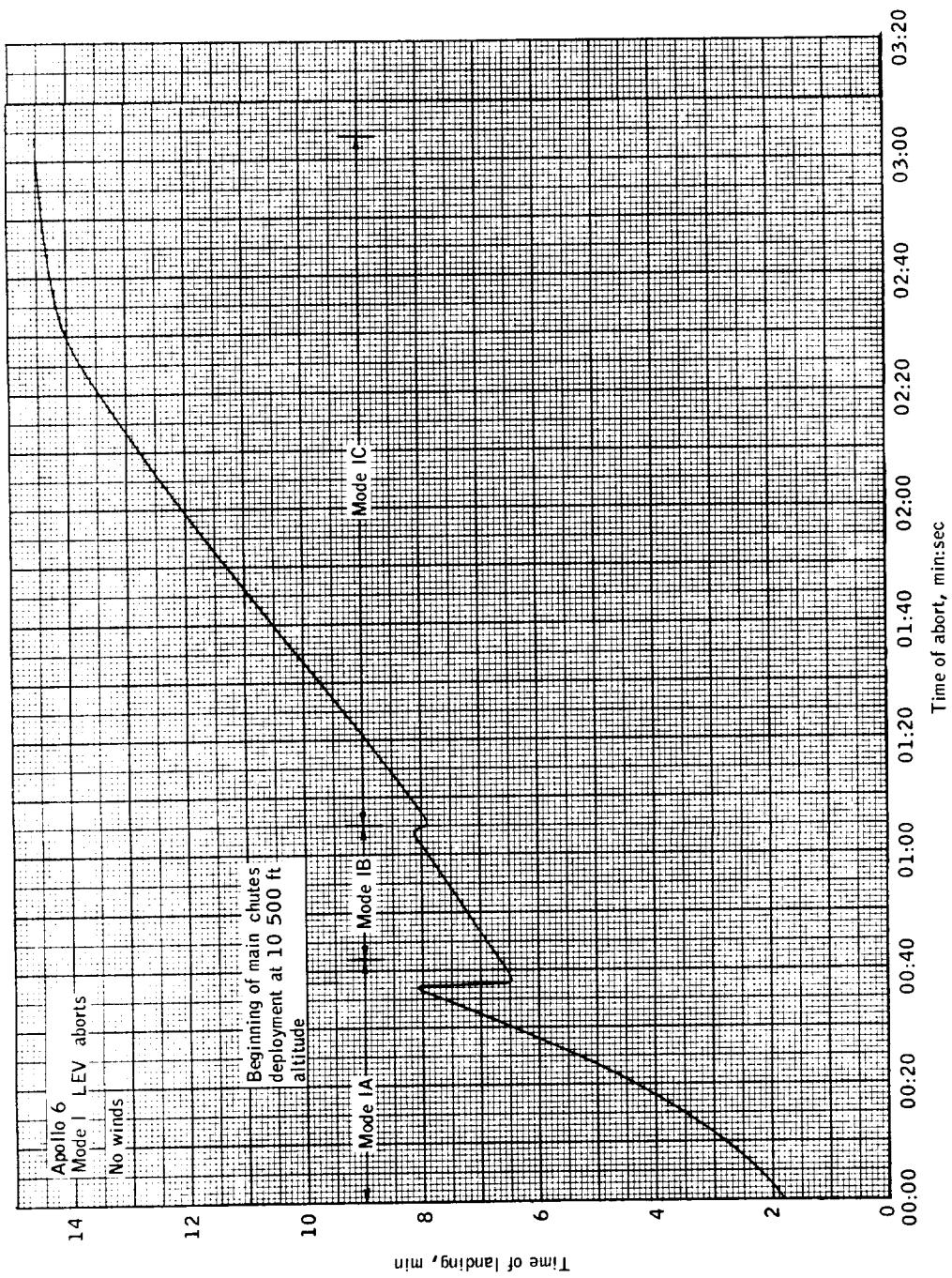


Figure 10.- Time of landing as a function of time of abort for mode I LEV aborts.

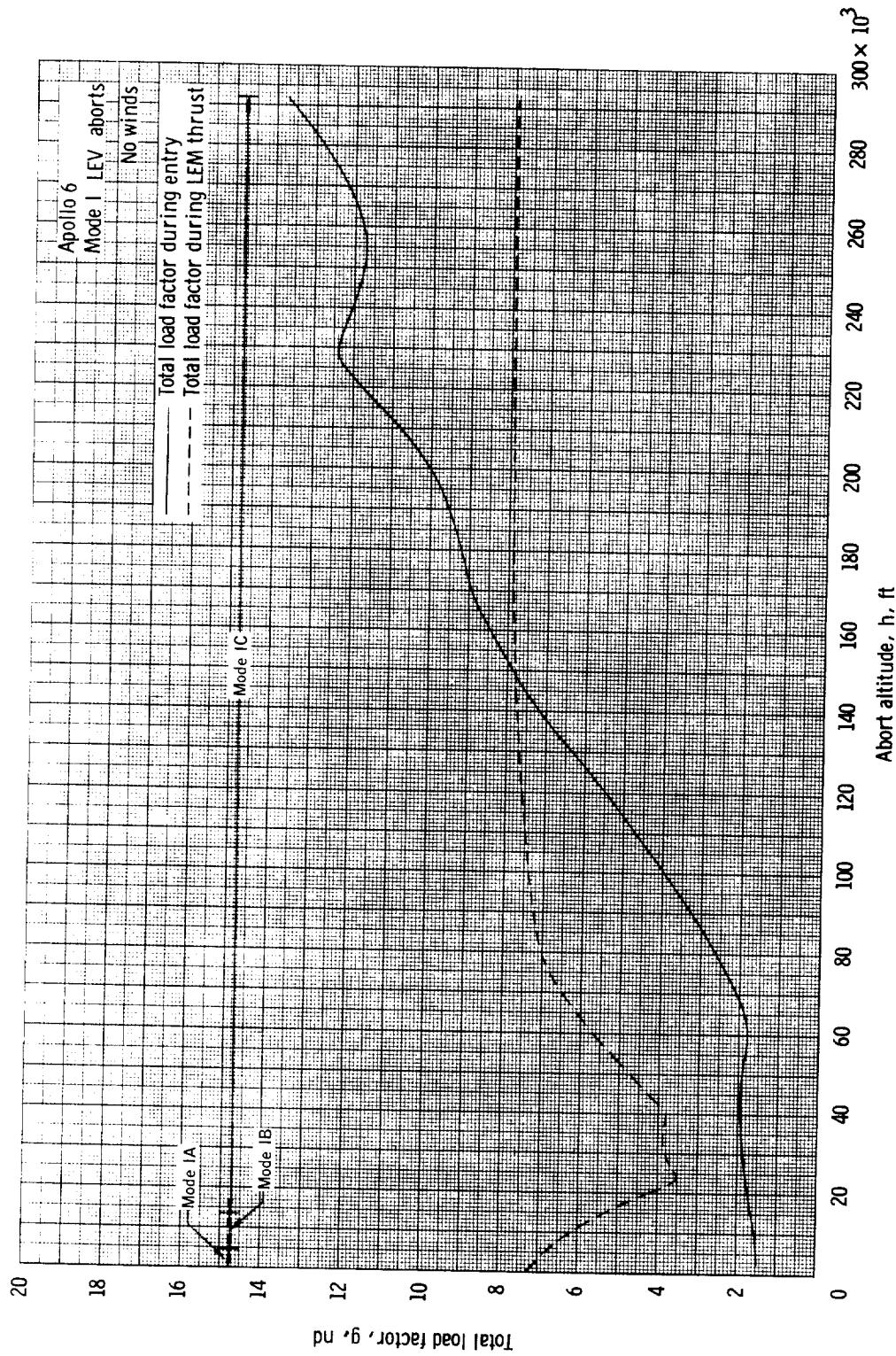


Figure 11. - Total load factor as a function of altitude of abort.

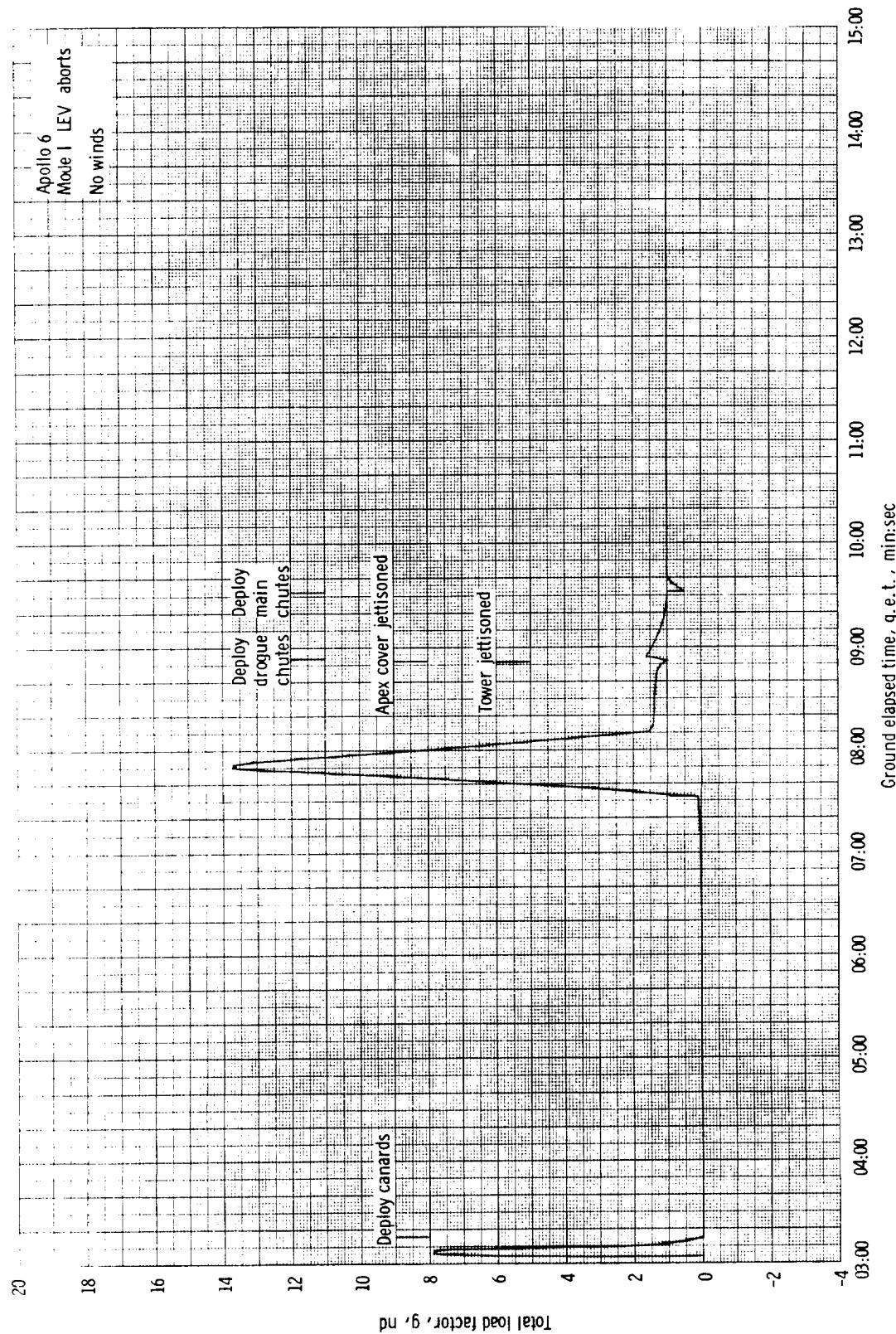


Figure 12. - Total load factor time history for a mode I LEV abort at 184.78 seconds.

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